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A SURVEY OF DWARFMISTLETOES IN ARIZONA AND NEW MEXICO

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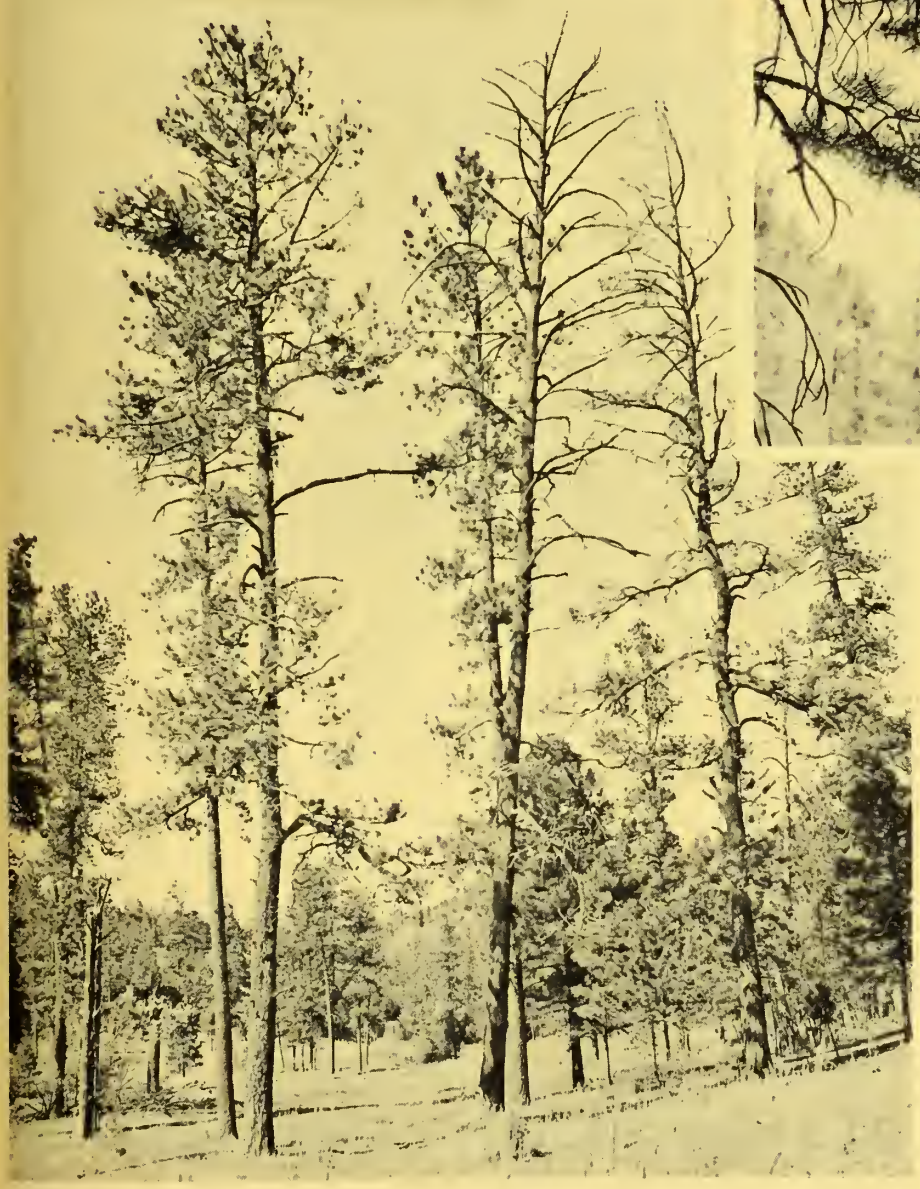

by

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and

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Stuart R. Andrews and John P. Daniels[1/]

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1/ Respectively, forest pathologist and formerly research forester, Rocky Mountain Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, with central headquarters maintained in cooperation with Colorado State University at Fort Collins.

A SURVEY OF DWARFMISTLETOES IN ARIZONA AND NEW MEXICO

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INTRODUCTION

Dwarfmistletoes are widespread, destructive disease agencies in the commercial forests of Arizona and New Mexico. One species (Arceuthobium vaginatum (Willd.) Presl) causes severe losses to ponderosa pine, the principal timber-producing tree in the region. Another species (A. douglasii Engelm.) is damaging to Douglas-fir, the next most important tree. A third species (A. campylopodum Engelm.) occasionally attacks other conifers.

Intensive surveys in the Grand Canyon National Park of Arizona[2/] and on the Mescalero Apache Indian Reservation of New Mexico (2, 5) provided the first quantitative estimates of dwarfmistletoe damage in large administrative units. These surveys suggested that the importance of dwarfmistletoes had been underrated and that they had become epidemic in some localities. Consequently, a regional damage-appraisal survey was begun about mid-July 1954 and completed early in September 1957. The survey covered all national forests and four of the five major timber-producing Indian reservations in Arizona and New Mexico. The Mescalero Apache Reservation was not included because it had been surveyed separately in 1952 and 1953 (5).

OBJECTIVES

The general objective of the survey was to evaluate the importance of dwarfmistletoes as a regional problem. Specifically, the survey was designed to help answer the following questions:

1. How widely are dwarfmistletoes distributed throughout Arizona and New Mexico on ponderosa pine and Douglas-fir?

2. Does the abundance of dwarfmistletoes vary in different parts of the region? To what extent is abundance associated with stand condition (virgin or cutover) and ecological factors?

3. Is dwarfmistletoe-associated mortality related to intensity of infection?

4. Can existing estimates of dwarfmistletoe-mortality losses be improved?

5. To what extent do dwarfmistletoes decrease yields?

2/ Gill, Lake S. An analysis of the mistletoe problem on ponderosa pine in the Grand Canyon National Park. 9 pp., illus. 1949. [Typewritten.]

METHODS

Before field work started each year, forests scheduled for survey were divided into convenient working areas consisting of ranger districts, working circles, or cutting units. Commercial timberland in the working areas then was delineated on forest maps.

The survey was conducted in two phases, using methods similar to those employed for surveying lodgepole pine dwarfmistletoe in Colorado and Wyoming (3). The first phase, a roadside traverse, provided general information on the distribution of dwarfmistletoes. The second phase, a plot survey, provided specific information on the abundance and severity of dwarfmistletoe infection and associated mortality losses in both the merchantable stand and the understory. The roadside traverse provided some information on dwarfmistletoes in forests where relatively few plots were established because of the small areas of commercial sawtimber.

ROADSIDE TRAVERSE

One or two men traversed roads in a slowly moving vehicle and watched for dwarfmistletoes in an estimated chain-wide strip, generally along the right-hand side of the roads. Road sections that had scenic strips or special silvicultural treatments were omitted. Changes in dwarfmistletoe occurrence, topography (ridge, slope, or bottom), timber type, and stand condition (virgin, old cutover, or recent cutover) were recorded to the nearest 1/20 mile. A standard of 40 to 60 miles of strip per 100,000 acres of commercial timberland was established for the traverse.

LINE-PLOT SURVEY

The line-plot survey was carried out by two-man crews under the general supervision of a survey pathologist. Clusters of 12 circular 1/4-acre plots with concentric 1/10-acre plots for submerchantable-size classes were established in each working area to provide about 48 plots for every 100,000 acres of commercial timberland. Plots that fell in the woodland type, grassland, cultivated, or nonproductive areas were discarded without replacement. Hence, some clusters had less than 12 plots.

Clusters were located on forest maps by the following procedure: For each working area, the intersection of a range and township line was designated as an origin, and rectangular coordinates for each cluster point were drawn from a table of random numbers. The starting point for each cluster was then determined by drawing a straight line to the nearest road. The resulting roadside point was henceforth considered the beginning point. It was located in the field by observing the mileage from some road intersection or other recognizable feature. A coin was flipped to determine if the cluster would be located to the left or right of the road. Lines were run at right angles to the contours or to roads in flat terrain.

In each cluster, plots were spaced randomly at the rate of six per mile along paired parallel straight lines. The center of the initial plot was 2 to 20 chains from the roadside starting point of the first line, and the centers of successive plots along the lines were separated by at least 2 chains. The

start of the second line, which was run in the reverse direction, was a random distance between 10 and 30 chains to the right from the end of the first line. Plots were located by pacing and using a hand compass.

Plot data were recorded directly on cards as explained in the appendix. Regional standards of merchantability were followed in tallying sawtimber trees, but the classification of poles deviated from common practice to conform with the Mescalero Apache Reservation survey (see appendix).

Periodic mortality was estimated from plot tallies of dead standing ponderosa pine and Douglas-fir with the bark intact. Trees with evidence of dwarfmistletoe attack were listed separately, and the d.b.h. and merchantable height were recorded for all sawtimber-sized trees.

RESULTS

A total of 3,053 plots were established in 520 man-days during the 4 years of the survey. The plots amounted to a 0.01 percent sample of the more than 8 million acres of commercial timberland in Arizona and New Mexico, exclusive of private holdings. The roadside traverse covered 3,440 miles, or slightly more than 40 miles per 100,000 acres of timberland.

The number of plots was nearly proportional to the area of commercial sawtimber in each forest (table 1). Figure 1 shows the approximate location of plot clusters. Mileage covered in the roadside traverse was also proportional to the commercial timberland in the various administrative units.

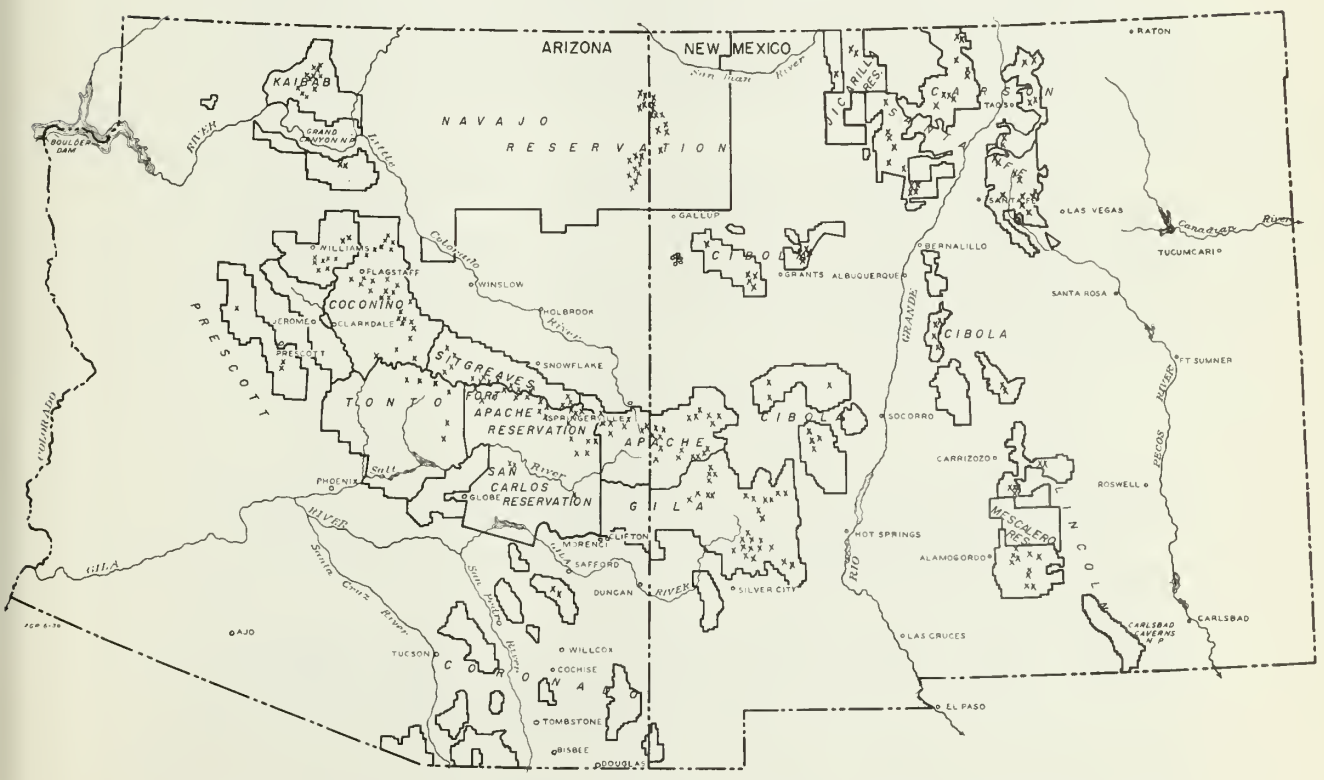

Figure 1.--Distribution of cluster sample; "x" indicates approximate location of each plot cluster

Table 1.--Allocation of line plots by administrative units and forest types as compared to distribution of commercial sawtimber

Administrative unit	Allocation of line plots							Distribution of commercial sawtimber	
	Ponderosa pine	Douglas-fir	True firs	Spruce	Limber pine	All types	Proportion of total	Area[1]	Proportion of total
	Number						Percent	M acres	Percent
National Forests:									
Kaibab	249	1	2	1	--	253	8	471	6
Coconino	310	4	--	--	--	314	10	862	10
Sitgreaves	154	2	6	--	--	162	5	482	6
Tonto	71	--	--	--	--	71	2	154	2
Prescott	29	--	--	--	--	29	1	77	1
Coronado	2	14	--	6	2	24	1	62	1
Apache	286	18	9	4	--	317	10	842	10
Gila	344	32	3	--	--	379	13	1,163	14
Cibola	279	13	2	--	--	294	10	1,005	12
Santa Fe	227	26	12	15	--	280	9	661	8
Carson	164	22	4	17	--	207	7	580	7
Lincoln	96	55	21	--	10	182	6	624	7
Indian Reservations:									
Navajo	245	13	--	--	--	258	9	548	7
Jicarilla	21	2	--	--	--	23	1	249	3
Fort Apache	208	4	7	8	--	227	7	453	5
San Carlos	33	--	--	--	--	33	1	117	1
Total	2,718	206	66	51	12	3,053	100	8,350	100

[1] Figures obtained from forest supervisors' offices and the Gallup Area Office, Bureau of Indian Affairs. Acreages include some areas now classified as noncommercial; wilderness areas, etc., are also included.

Eighty-nine percent of the plots were located in the ponderosa pine type, 7 percent in the Douglas-fir type, and the remaining 4 percent in true fir, spruce, and limber pine types as defined in the appendix (table 1). Virgin stands contained 40 percent of the plots,[3] old cutover areas 29 percent, and recent cutover areas[4] 31 percent. Nearly 92 percent of the plots were located on slopes.

The following discussion deals with summaries of the data that were restricted to the predominant species in each type, i.e., dwarfmistletoe abundance and severity in terms of trees or merchantable volumes relate only to ponderosa pine in the ponderosa pine type. This procedure resulted in relatively low volumes of timber per acre in the Douglas-fir type, where other species often make up nearly 50 percent of the stand.

EXTENT OF INFECTION

Ponderosa pine dwarfmistletoe is widely distributed throughout the ponderosa pine sawtimber stands of Arizona and New Mexico. It was found

3/ As compared with 38 percent of the area, an estimate derived from statistics in Timber Resources for America's Future (7). This estimate was based on the following assumptions: that in 1952, the base year of the inventory (loc. cit.), virgin stands accounted for 82 percent of the acreage classified as old-growth sawtimber and 40 percent of that in submerchantable-sized classes; and that the virgin sawtimber area had been reduced by 400,000 acres by the end of 1956 when about one-half of the region had been covered by the dwarfmistletoe survey. The first assumption was necessary because commercial forest land area was subdivided according to stand-size classes in the 1952 inventory (loc. cit.) rather than by stand condition.

4/ Old cutover and recent cutover areas are defined in the appendix.

on all forests and reservations surveyed, with the exception of the San Carlos Indian Reservation (table 2). The parasite occurred on 36 percent of the plots in the ponderosa pine type, and was estimated to be present on 2.5 million acres of commercial ponderosa pine timberland.

Table 2. --Proportion of plots and ponderosa pine sawtimber areas with dwarfmistletoes by administrative units

Administrative unit	Plots		Ponderosa pine sawtimber area	
	Total	Proportion infected	Total 1/	Estimated infected 2/
	No.	Percent	M acres	
National Forests:				
Kaibab	249	30	405	120
Coconino	310	30	831	250
Sitgreaves	154	33	454	150
Tonto	71	15	151	20
Prescott	29	3/ 10(15)	74	10
Coronado	2	3/ 0(20)	42	10
Apache	286	46	652	300
Gila	344	35	1,067	370
Cibola	279	45	955	430
Santa Fe	227	41	408	170
Carson	164	32	418	130
Lincoln	96	64	297	190
Indian Reservations:				
Navajo	245	27	536	140
Jicarilla	21	3/ 5(10)	244	20
Fort Apache	208	47	404	190
San Carlos	33	4/ 0	117	0
Total	2,718	36	7,055	2,500

1/ These total acreage figures include some areas now classified as noncommercial; wilderness areas, etc., are also included.

2/ Rounded off to the nearest 10,000 acres.

3/ Figures in parentheses are adjustments based on roadside survey where plot samples were small.

4/ Two out of three logging units. The third unit (Malay Gap) was not surveyed because of inaccessibility during rainy season. The parasite is known to be present in this general area on ponderosa pine.

Douglas-fir dwarfmistletoe is also widespread in the region. It occurred on nearly one-half the Douglas-fir plots, and is estimated to be present on about 275,000 acres of the type, as classified in this survey.

The survey revealed little information on the occurrence of dwarfmistletoes on other tree species. True fir, spruce, and limber pine occur mainly at higher elevations, which were not adequately sampled.

Dwarfmistletoes were found on true fir on six fir-type plots distributed over the Apache, Gila, and Lincoln National Forests and the Fort Apache Indian Reservation. They have also been collected on the Coconino and Coronado National Forest (1), and on the North Rim of the Grand Canyon.

Dwarfmistletoes were found on spruce on eight plots of the spruce type located on the Apache National Forest and the adjacent Fort Apache Reservation. The parasites have also been collected on the Coronado and Gila National Forests (1), and on the North Rim of the Grand Canyon.

Dwarfmistletoes were found on limber pine on seven survey plots located on the Apache, Gila, and Lincoln National Forests. The parasite is also known to attack this tree in the Coronado National Forest (1).

Ponderosa pine dwarfmistletoe was more abundant in the Sacramento-White-Capitan Mountain area of New Mexico than elsewhere in the region. It was found on almost two-thirds of the ponderosa pine type plots on the Lincoln National Forest (table 2). Furthermore, on the neighboring Mescalero Apache Reservation it was present on more than one-half the plots established in the type during an earlier survey (2, 5). The parasite was nearly as abundant on the Apache National Forest and the Fort Apache Indian Reservation, where it occurred on almost one-half the plots in the ponderosa pine type (table 2). It was almost as common on the Cibola and Santa Fe National Forests, although the samples in these two forests were not so well distributed because of a large proportion of relatively inaccessible areas.

The abundance of ponderosa pine dwarfmistletoe approximated the regional average on the Coconino, Kaibab, Sitgreaves, Gila, and Carson National Forests. It was less common on the Navajo Indian Reservation. The roadside traverse and other observations suggest that dwarfmistletoes were more abundant in some parts of the Prescott, Tonto, and Coronado National Forests than the plot survey indicated. On the San Carlos Indian Reservation, the Malay Gap logging unit, which was omitted from the survey (table 2, footnote 4), adjoins the heavily infected Apache National Forest and Fort Apache Indian Reservation. It would be unusual if dwarfmistletoes were not present in this unit.

EFFECTS OF STAND CONDITION

Ponderosa pine dwarfmistletoe was more abundant in virgin than in cutover stands. In the roadside traverse, dwarfmistletoes were observed in 30 percent of the strips in virgin stands, 21 percent in old cutover areas, and 22 percent in recently cutover areas. The following tabulation gives the abundance as calculated from the line plots:

Stand condition	Plots (No.)	Proportion of total (Pct.)	Plots with dwarfmistletoes 5/ (Pct.)
Virgin	1,020	38	39
Old cutover	794	29	33
Recent cutover	904	33	35
Total	2,718	100	36

5/ Chi-square tests showed a significant difference between virgin and the old cutover area, but differences between either virgin and recent cutover or virgin and combined cutover areas were not significant.

Infection in ponderosa pine was also more severe in virgin than in cutover stands (table 3). In virgin stands, 25 percent of the merchantable trees had dwarfmistletoes compared with 19 percent in both old and recently cutover areas. Infected trees accounted for 22 percent of the total volume in virgin stands, 17 percent in old cutover, and 18 percent in recently cutover stands. Infection of poles in virgin stands was 12 percent as compared with 6 percent in old and 8 percent in recently cutover stands.

Table 3.--Dwarfmistletoe infection in virgin and cutover ponderosa pine stands (per-acre basis)

Stand condition, number of plots, and size class	Trees		Volume	
	Total	Proportion infected	Total	Proportion infected
	No.	Pct.	Bd. ft.	Pct.
Virgin (1,020 plots)				
Merchantable	21.7	25	5,530	22
All poles	241.9	12	--	--
Old cutover (794 plots)				
Merchantable	17.4	19	3,330	17
All poles	406.0	6	--	--
Recently cutover (904 plots)				
Merchantable	23.0	19	4,500	18
All poles	258.3	8	--	--

Dwarfmistletoe will probably intensify more rapidly on the recent cutover than on the old cutover areas because the residual stands on the former were considerably heavier and in general included more infective overstory trees.

EFFECTS OF ECOLOGICAL FACTORS

Topographic position

The roadside strip and the line-plot survey confirmed previous findings (2, 4, 6) that ponderosa pine dwarfmistletoe was most abundant on ridges. On the roadside strip the parasite was seen on 62 percent of the ridges, 25 percent of the slopes, and in 8 percent of the bottoms. The following tabulation shows abundance as calculated from the line plots.

Topographic position	Plots (No.)	Proportion of total (Pct.)	Plots with dwarfmistletoes 6/ (Pct.)
Ridge	125	5	57
Slope	2,497	92	36
Bottom	96	3	16
Total	2,718	100	36

6/ Chi-square tests showed that the differences in abundance of dwarfmistletoes in all three topographic positions were highly significant.

Since only a small proportion of the ponderosa pine type is involved, the abundance of dwarfmistletoes on ridges has little practical significance except as a source of infection for stands in other positions.

Infection in terms of merchantable trees and volumes was most severe on ridges where 27 percent of the merchantable trees had dwarfmistletoes, as compared with 22 percent on slopes, and only 8 percent in bottoms (table 4). Infected trees accounted for 27 percent of the total merchantable volume on ridges, 19 percent on slopes, and 6 percent in the bottoms.

Infection in poles followed the same trend: 11, 8, and 3 percent on ridges, slopes, and bottoms, respectively.

Table 4. --Dwarfmistletoe infection in ponderosa pine stands on ridges and slopes and in bottoms (per-acre basis)

Topographic position, number of plots, and size class	Trees		Volume	
	Total	Proportion infected	Total	Proportion infected
	No.	Pct.	Bd. ft.	Pct.
Ridge (125 plots)				
Merchantable	22.8	27	4,390	27
Poles	337.0	11	--	--
Slope (2,497 plots)				
Merchantable	20.9	22	4,530	19
Poles	297.1	8	--	--
Bottom (96 plots)				
Merchantable	17.8	8	4,830	6
Poles	194.5	3	--	--

Elevation, Aspect, and Degree of Slope

Dwarfmistletoe abundance increased directly with elevation (fig. 2). This is contrary to earlier reports that it was most prevalent at the lower limits of the ponderosa pine type (6). This finding also seems to vary from results obtained in the intensive survey of the Mescalero Apache Reservation that indicated dwarfmistletoes occurred most frequently in the intermediate altitudinal range, where the bulk of the commercial sawtimber grows (4). The regional survey covered a wider range of elevations and latitudes; hence, some difference was expected.

Although the parasite has been reported to be most abundant on south-facing slopes (6), the line-plot survey did not confirm this, and it failed to reveal any correlation between infection and aspect. The relationship between infection and degree of slope (see appendix) was also analyzed. For the region as a whole, dwarfmistletoe was most abundant on moderate rather than gentle slopes. The difference in frequency between moderate and steep slopes was not significant; whereas, the difference between gentle and either moderate or steep slopes was highly significant.

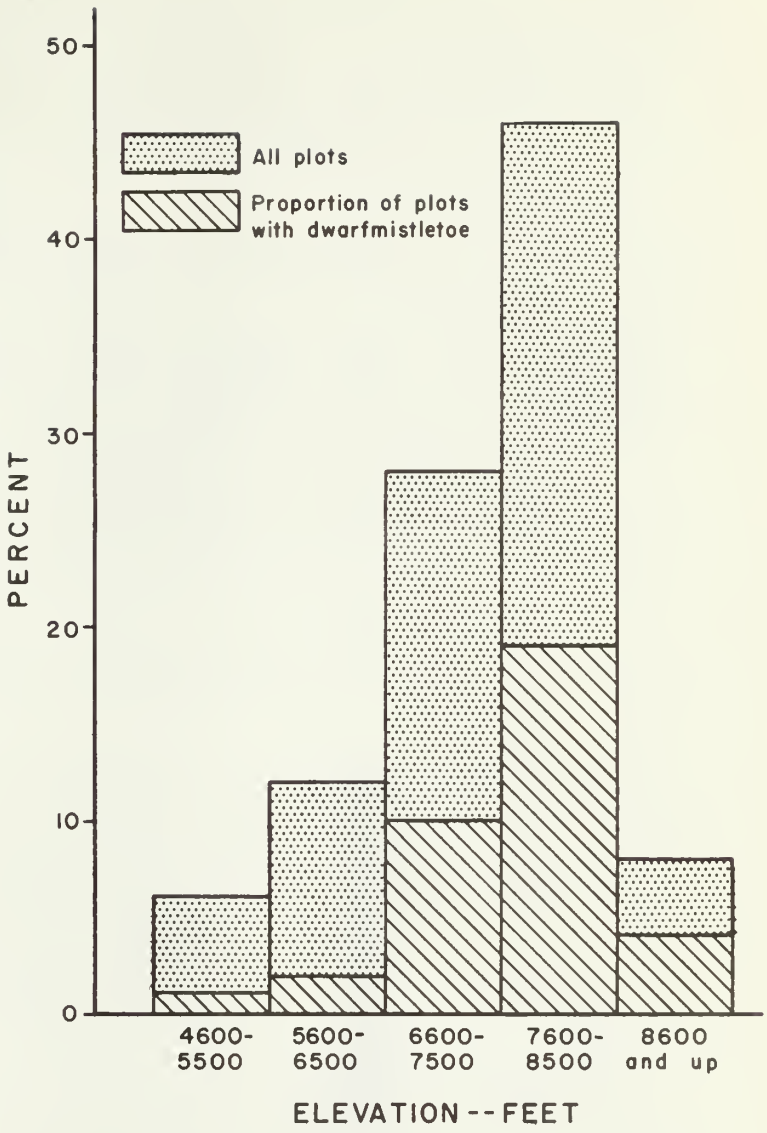

Figure 2.--

Ponderosa pine dwarfmistletoe abundance by elevation classes. Basis: 2,164 plots for which elevations were determined.

INCREASED MORTALITY

Dwarfmistletoe-infected ponderosa pine plots had significantly more recently dead trees per acre than healthy plots, and such trees had about twice as much gross volume per acre (table 5). Expressed as percentages of the totals for living and dead trees combined, periodic mortality losses in both trees and volume were about twice as heavy in the infected stands. These differences were more pronounced in virgin than in cutover areas (fig. 3). Furthermore, the number of recently dead merchantable-sized trees was significantly greater on plots with 81 to 100 percent infection than on less heavily infected plots (9.6 as compared with 5.3 percent of the total number of living and dead trees). Plots with dwarfmistletoes also had about twice as many dead poles per acre, but percentagewise pole mortality was only about one-third greater in the diseased stands.

Table 5. --Comparison of periodic mortality in infected and healthy ponderosa pine plots (per-acre basis) -- 2,718 plots

Disease condition, number of plots, and size class	Trees			Volume		
	Living	Dead	Periodic mortality[1]	Living	Dead	Periodic mortality[2]
	No.		Pct.	Bd. ft.		Pct.
Infected (983 plots)						
Merchantable	25.6	1.7	6.6	4,700	340	7.2
Poles	371.4	16.3	4.4	--	--	--
Healthy (1,735 plots)						
Merchantable	18.2	0.5	2.7	4,450	160	3.6
Poles	252.2	8.4	3.3	--	--	--

[1] Number of recently dead standing trees with bark intact expressed as a proportion of total number of living and dead merchantable-sized trees.

[2] Volume of recently dead standing trees with bark intact expressed as a proportion of total volume of living and dead merchantable-sized trees.

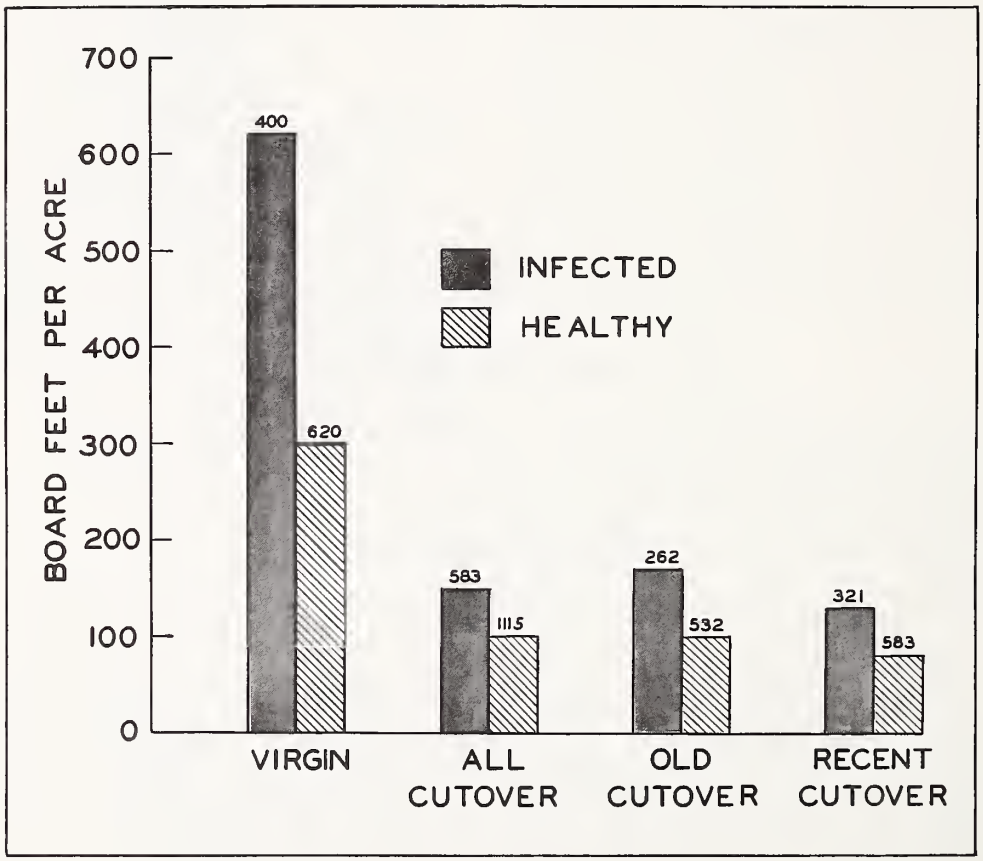

Figure 3. --Periodic mortality of merchantable-sized ponderosa pine as related to dwarfmistletoe occurrence and stand condition. Numbers above bars are plot bases.

Infected Douglas-fir plots had four times as many dead trees per acre as healthy stands, and these dead trees also contained four times as much gross volume per acre (table 6). On a percentage basis, differences were in the order of three times for both number of trees and volume. In contrast to ponderosa pine, these differences were more pronounced in cutover than in virgin areas (fig. 4). Plots with dwarfmistletoes also had 3-1/2 times more dead poles. When difference in the number of stems per acre is taken into account, mortality was about 2-1/2 times greater on the infected plots.

Table 6. --Comparison of periodic mortality in infected and healthy Douglas-fir plots (per-acre basis) -- 206 plots

Disease condition, number of plots, and size class	Trees			Volume		
	Living	Dead	Periodic mortality	Living	Dead	Periodic mortality
	No.		Pct.	Bd. ft.		Pct.
Infected (97 plots)						
Merchantable	17.5	3.4	19.4	3,400	760	22.4
All poles	194.0	17.7	9.1	--	--	--
Healthy (109 plots)						
Merchantable	14.6	0.8	5.5	2,810	180	6.4
All poles	144.5	5.0	3.5	--	--	--

Annual mortality losses associated with ponderosa pine dwarfmistletoe were estimated to be 44 million board feet in 1952 (7). Results of the regional survey indicate that this figure should be raised to at least 55 million. It also appears that the earlier loss estimate of 8 million board feet for Douglas-fir was too low and should be raised to at least 20 million board feet.

Depending upon whether the difference in periodic losses between infected and uninfected ponderosa pine plots (table 5) was divided by 8 years or 6 years, annual losses associated with infection amounted to either 22 or 30 board feet per acre. These losses totaled 55 to 75 million board feet for the estimated 2,500,000 acres of the ponderosa pine type with dwarfmistletoe. Recently dead trees, as tallied in this survey, were considered to have died within the preceding 8 years on the Mescalero Apache Reservation (5), but more recent observations on sample plots in the Grand Canyon National Park indicate that 6 years may be more nearly correct for northern forests.

Periodic mortality on infected Douglas-fir plots averaged 760 board feet per acre as compared with 180 board feet for uninfected plots (table 6). Hence, annual losses were between 72 and 97 board feet per acre, or between 20 and 27 million board feet for the 275,000 acres of Douglas-fir with dwarfmistletoes.

These estimates actually apply to 1956, the base year of the dwarfmistletoe survey. Presumably ponderosa pine losses were greater in 1952, and they should be smaller today because the acreage in virgin stands is reduced each year by harvest cuttings. Apparently this does not apply to Douglas-fir because plot mortality was heavier in cutover than in virgin plots.

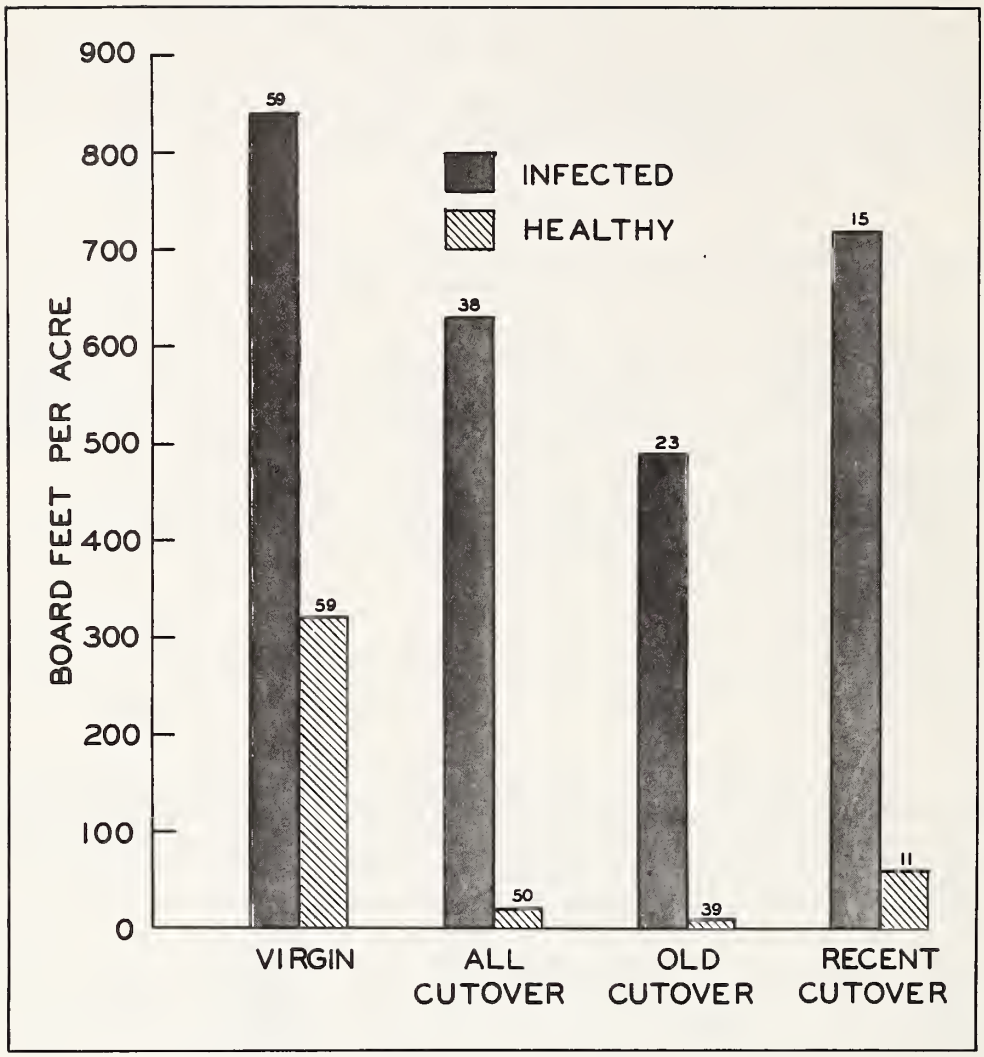

Figure 4. --Periodic mortality of merchantable-sized Douglas-fir as related to dwarfmistletoe occurrence and stand condition. Numbers above bars are plot bases.

Confidence intervals for the estimates could not be computed. However, the revised figures appear to be conservative. Comparisons limited to plots in virgin ponderosa pine stands on slopes suggest that the estimates would have been 1-1/2 times higher if they had been based on mortality of infected trees alone.

REDUCTION OF YIELDS

Because of the significant mortality losses associated with dwarfmistletoe infection, it seems anomalous that infected plots in the ponderosa pine type should show a somewhat higher average yield than healthy plots (see table 5).

This is undoubtedly influenced by the fact that infection is relatively infrequent at the lower limits of the ponderosa pine type where growth is slow and stands are open. Figure 2, for example, shows that below elevations of 6,500 feet, less than 20 percent of the plots were infected; whereas, in the optimum pine zone of 6,600 to 8,600 feet infection ranged from 35 to 40 percent. Furthermore, the mere presence of dwarfmistletoes in an area does not necessarily mean that yields have been reduced. Time is needed for the effects of parasitism to become manifest. Severity or intensity of infection, therefore, must be considered in evaluating losses.

To provide an indication of the effects of dwarfmistletoe on yield, all virgin ponderosa pine slope plots with dwarfmistletoe in merchantable-sized trees have been grouped into three infection-intensity classes (table 7). Plot ratings were obtained by adding the infection-intensity class numbers (see appendix) of all infected trees and dividing by the total number of merchantable stems on a plot.

Table 7.--Merchantable stands per acre and periodic mortality associated with dwarfmistletoe severity in virgin ponderosa pine stands on slopes

Infection intensity rating[1]	Merchantable			Periodic mortality			
	Trees	Volume		Trees	Volume		
		Per tree	Total		Per tree	Total	Proportion[2]
	No.	Bd. ft.		No.	Bd. ft.		Pct.
0.1 - 2.0 (201 plots)	31.6	209	6,620	2.4	208	500	7
2.1 - 4.0 (128 plots)	24.1	227	5,470	2.6	265	690	13
4.1 - 6.0 (21 plots)	14.5	273	3,970	3.6	256	920	19

[1] Plot ratings were obtained by adding the infection-intensity class numbers (see appendix) of all infected trees and dividing by the total number of merchantable stems on a plot.

[2] The volume in standing dead merchantable trees with bark intact is expressed as a percentage of the total (living plus dead) merchantable volume.

As intensity of infection in the sawtimber stand increased, the average number of living trees and merchantable volumes per acre decreased; whereas the average number of dead trees and periodic mortality increased (table 7). Infected plots with a light intensity rating (0.1-2.0) had an average volume per acre of 6,620 board feet in contrast to 5,470 board feet for the moderate (2.1-4.0) class; a difference of 1,150 board feet or a 17 percent reduction in yield. The merchantable volumes of recently dead trees in the same two classes averaged 500 to 690 board feet per acre, respectively, a difference of 190 board feet, or a 38 percent increase in periodic mortality. The effect of dwarfmistletoe infection on yields was even more marked in the 4.1 to 6.0 class. However, the plot basis suggests that a relatively small proportion of the virgin stands on slopes is in this class.

By comparison, 509 healthy plots in virgin stands on slopes had an average merchantable volume per acre of 6,090 board feet and periodic mortality amounting to 340 board feet per acre or less than 6 percent.

The survey data cannot be used to determine growth losses associated with dwarfmistletoe infection. This is apparent from the fact that the average merchantable volume per tree increased directly with infection intensity (see table 7). On the one hand, differences in average size may indicate site differences or differences in the average age of plot trees. On the other, they probably express the selectiveness of dwarfmistletoe-associated mortality in which trees that suffered the greatest growth reduction were the first to die. The remaining large living trees would not provide much evidence of growth loss even though they received high infection intensity ratings during the survey.

SUMMARY

A survey of dwarfmistletoes on ponderosa pine, Douglas-fir, and other species in Arizona and New Mexico was begun in 1954 and completed in 1957. The survey covered all major timber-producing areas of the region, with exception of the Mescalero Apache Reservation that had been surveyed previously.

General observations on the distribution of dwarfmistletoes were made along more than 3,400 miles of road in one phase of the survey. In the other phase 3,000 quarter-acre circular plots were established to give a 0.01 percent sample of the region's commercial sawtimber area.

Eighty-nine percent of the plots were located in the ponderosa pine type and dwarfmistletoes were found on 36 percent of them. On this basis it is estimated that the parasite is present on at least 2.5 million acres of the type. About 7 percent of the plots were located in stands classified as the Douglas-fir type, and of these 47 percent had dwarfmistletoes. It is estimated that about 275,000 acres of Douglas-fir are infected. The remaining plots were scattered throughout stands in which other conifers predominated. The limited sample obtained suggests that dwarfmistletoes are not widespread in these other types.

Ponderosa pine dwarfmistletoe was most abundant on the Lincoln and Apache National Forests and the Fort Apache Indian Reservation. It was most abundant in virgin stands and on ridges. No relationship was found between dwarfmistletoe occurrence and aspect, but abundance increased directly with elevation.

Severity of dwarfmistletoe infection in terms of the number and volumes of merchantable trees affected was closely related to abundance. It was greatest in virgin stands and on ridges.

Mortality was heavier in infected than in uninfected stands: three times as many merchantable trees with twice as much volume had died recently in the ponderosa pine type. In Douglas-fir, stands with dwarfmistletoe had four times as many dead trees as healthy stands and also four times as much merchantable volume in dead trees. Mortality was significantly greater in heavily infected stands.

Previous estimates of mortality losses associated with dwarfmistletoes have been revised as a result of the survey. It is now estimated that annual mortality losses alone total 55 to 75 million board feet in ponderosa pine and 20 to 27 million feet in Douglas-fir. Analysis of data for plots located in virgin ponderosa pine stands on slopes provide some indication of the effect of dwarfmistletoe on yields. Average merchantable volumes per acre dropped as infection intensity increased; whereas periodic mortality increased. Infected plots with light intensity ratings had an average volume per acre of 6,620 board feet per acre in contrast to 5,470 board feet for the moderate class; a difference of 1,150 board feet or a 17 percent reduction in yield. Periodic mortality in these same two classes averaged 500 and 690 board feet per acre, respectively, a difference of 190 board feet or a 38 percent increase in mortality loss. By comparison, healthy plots in virgin ponderosa pine on slopes had an average merchantable volume per acre of 6,090 board feet and periodic mortality of 340 board feet. The survey data cannot be used to determine growth losses associated with dwarfmistletoe infection.

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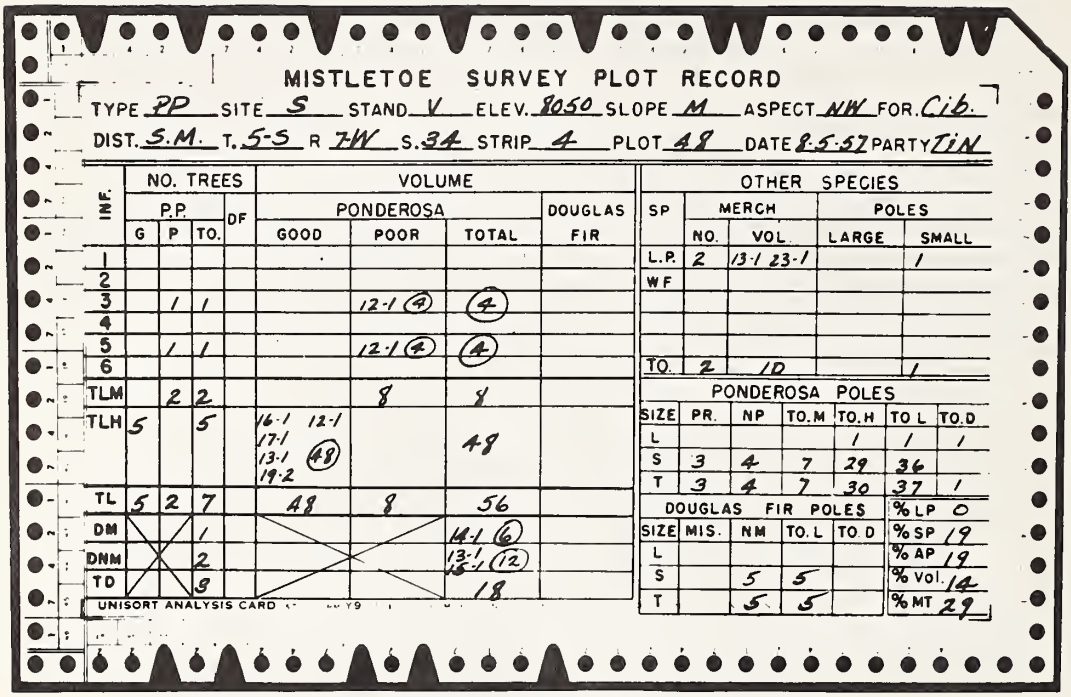
APPENDIX



MISTLETOE SURVEY PLOT RECORD

TYPE PP SITE S STAND V ELEV. 8050 SLOPE M ASPECT NW FOR. Cib.

DIST. S.M. T. 5-S R 7W S. 34 STRIP 4 PLOT 48 DATE 8-5-57 PARTY TIN

INF.	NO. TREES PP G	NO. TREES PP P	NO. TREES PP TO.	NO. TREES DF	VOLUME PONDEROSA GOOD	VOLUME PONDEROSA POOR	VOLUME PONDEROSA TOTAL	VOLUME DOUGLAS FIR
1								
2								
3		1	1			12-1 (4)	(4)	
4								
5		1	1			12-1 (4)	(4)	
6								
TLM		2	2			8	8	
TLH	5		5		16-1 12-1 17-1 13-1 19-2 (48)		48	
TL	5	2	7		48	8	56	
DM			1				14-1 (6)	
DNM			2				13-1 15-1 (12)	
TD			3				18	

UNISORT ANALYSIS CARD

OTHER SPECIES

SP	MERCH NO.	MERCH VOL.	POLES LARGE	POLES SMALL
L.P.	2	13-1 23-1		1
WF				
TO.	2	10		1

PONDEROSA POLES

SIZE	PR.	NP	TO.M	TO.H	TO L	TO.D
L				1	1	1
S	3	4	7	29	36	
T	3	4	7	30	37	1

DOUGLAS FIR POLES

SIZE	MIS.	NM	TO. L	TO. D
L				
S		5	5	
T		5	5	

% LP 0
% SP 19
% AP 19
% VOL. 14
% MT 29

Sample of the Unisort Analysis Card used to record data from the plots

MISTLETOE SURVEY PLOT RECORD

Information Recorded and Explanation of Abbreviations Used

Type: PP = ponderosa pine (Pinus ponderosa Laws.)
DF = Douglas-fir (Pseudotsuga menziesii var. glauca [Beissn.] Franco)
WF = white fir (Abies concolor [Gord. & Glend.] Lindl.) and (A. lasiocarpa [Hook.] Nutt.)
SP = spruce (Picea pungens Engelm. and P. engelmannii Parry)
LP = limber pine (Pinus flexilis James)
The species comprising 50 percent or more of the overstory determined the type.

Site: R = ridge; B = bottom; S = slope.

Stand: V = virgin; OC = old cutover; RC = recent cutover. The breaking point between old and recent cutover was 15 years as determined from available records or as estimated from condition of cut stumps. Bulk of stands classified as recently cut-over were logged by the light improvement-selection method.

T, R, S: Township, Range, Section

Elevation: Aneroid determination, above sea level. Aneroid barometer was checked each morning, if possible, at a point of known elevation and at other points of known elevation as they were encountered.

Slope: L = level (less than 5%)
G = gentle (5-10%)
M = moderate (10-30%)
S = steep (over 30%)

Aspect: One of eight major aspects.

For.: National Forest or Indian Reservation.

Dist.: Ranger district or unit.

Strip: Numbered consecutively in each forest, starting with 1.

Plot: Distance in chains from the starting point of each strip.

Date: Year, month, day.

Party: Initials of party members.

Totals: TO.; T.
TLM = total number and volume in dwarfmistletoe-infected trees.
TLH = total number and volume of healthy trees.
TL = totals for all living trees.

Infection-intensity rating: INF = Determined for ponderosa pine and Douglas-fir only. Live crowns of dwarfmistletoe-infected merchantable trees were divided into thirds. Each third was rated as healthy (0), lightly (1), or heavily (2) infected, and the three figures added. Hence, class 3 [or 0 + 1 + 2 = 3] could mean lightly infected throughout the crown, whereas class 5 could only mean heavily infected in two-thirds and lightly infected in the remaining one-third.

Risk: G = good; P = poor, under column headed No. trees. Estimated for ponderosa pine only. Each tree was rated on needle color and length as well as overall appearance.

Volume: VOL = All merchantable-sized trees were tallied by d.b.h. and height (in 16-foot logs) to an 8-inch top in appropriate volume columns. Gross volumns were later determined from Region 3 volume tables (Scribner Decimal C), entered on card, and totaled for the plot. They are circled figures on the sample card.

Dead trees: Standing dead ponderosa pine and Douglas-fir with the bark intact were tallied by d.b.h. and merchantable height. Trees with evidence of dwarfmistletoes (DM) were tallied separately from all others (DNM). TD = total number and volume of dead trees.

Poles: Ponderosa pine and Douglas-fir only on 1/10-acre concentric plots.

L = large poles (trees 7.6 to 11.5 inches d.b.h.)

S = small poles (trees over 6 ft. high to 7.5 inches d.b.h.)

Ponderosa pine tallied as:

PR = prunable; no dwarfmistletoes above 17 feet nor within 12 inches of trunk.

NP = not prunable; dwarfmistletoes above 17 feet or within 12 inches of trunk.

TO. M. = total with dwarfmistletoes.

TO. H. = total without dwarfmistletoes.

TO. L. = total living.

TO. D. = total dead.

Douglas-fir tallied as:

MIS = dwarfmistletoe infected.

NM = dwarfmistletoe free.

TO. L. = total living.

TO. D. = total dead.

Percent dwarfmistletoe (ponderosa pine or Douglas-fir): [lower right-hand corner]

% LP = percent large poles infected.
% SP = percent small poles infected.
% AP = percent all poles infected
% Vol. = percent merchantable volume in dwarfmistletoe-infected trees.
% MT = percent merchantable trees infected.

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